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in connection with Application No. 2003905353 for a patent by CAST CENTRE
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AUSTRALIA

PATENTS ACT 1990

PROVISIONAL SPECIFICATION

for the invention entitled:

“ Developments Relating to Die Casting and Moulding ”

The invention is described in the following statement:

Developments Relating to Die Casting and Moulding

5 Field of the Invention

This invention concerns the construction and operation of chill vents and vacuum valves associated with casting dies for the high pressure die casting of metals. It is particularly adapted to use in the manufacture of components cast of metals such as
10 aluminium, magnesium or zinc alloys. It may also be applied to the injection moulding of plastics components.

Background to the Invention

15 Gas entrapment often occurs in the high pressure die casting (HPDC) process for production of metal products. The entrapped gas forms porosity in the castings that can result in rejects and/or make them unsuitable for heat treatment.

A common practice in the industry to eliminate gas entrapment is to apply a vacuum
20 technique during cavity filling. In the cold chamber process of HPDC, cavity filling takes place within a few to tens of milliseconds. The effective gas evacuating time is only a few seconds. The amount of gas evacuated will depend upon the efficiency of the vacuum system applied.

25 The vacuum valve is a critical component in the vacuum system. It opens to apply vacuum to the cavity and later closes to prevent metal entering the vacuum valve mechanism and the vacuum supply system. The efficiency of the vacuum system depends on the type of vacuum valve used. In a simple vacuum system the valve is shut off via a micro-switch triggered by the injection plunger position. However,
30 after the valve is closed but before the cavity is full, air can be drawn back into the cavity through parting lines in the die.

Other types of valves, such as the Fondarex and GF (Gas Free) valves, are mechanically closed by the metal pressure built up during the final stages of cavity filling. This type of valve is much more efficient than that in a simple vacuum
5 system because it can keep extracting gas from the cavity until the cavity is nearly full. However, its complex mechanical triggering device contributes to high capital and maintenance costs. It is also prone to malfunction and can cause expensive machine down-time.

- 10 The present invention provides a vacuum valve which is simple to manufacture, has reduced maintenance costs and reduced downtime when compared with existing vacuum valves.

Another common practice in the industry is to use a chill vent to naturally vent the
15 gas from the cavity without application of a vacuum. Typically a chill vent consists of two halves, each half being a metal block, which are held to form a thin generally planar gap of zigzag shape between the halves. Gas can be vented through the gap but metal entering the gap is chilled and solidifies, to eventually block the gap. The metal solidified in the chill vent forms a generally planar washboard-like appendage
20 to the casting, oriented in or parallel to the die parting face.

The thickness of the gap within the chill vent must be small to capture and solidify the metal which exits the die cavity at high speed. But reducing the thickness of the gap reduces the cross section area of the gap and thus restricts the venting efficiency.
25 To provide a compensating increase in the cross-section area, the chill vent has to be made wider, but this will accordingly increase the projected area of the die, thus increasing the force tending to separate the die parts, and therefore increase the risk of die flash.

- 30 The present invention provides a chill vent which has improved performance by having increased surface area without the usual consequent increase in projected area of the die.

The invention may thus provide a vacuum valve and/or a chill vent. In this specification the term "vent means" is used to encompass both vacuum valves and chill vents.

5

Summary of the Invention

In one aspect the invention provides apparatus for forming a solid product from a melt, said apparatus including a vent means, the vent means having two relatively
10 movable structures, a first of said structures having a wedge-shaped member which moves into engagement with a wedge-shaped slot in the second of said structures,

the wedge-shaped member having:

- a pair of wedge main faces aligned to each other at a taper angle to form a thin end and a thick end of said wedge-shaped member, and
- 15 — a wedge end face extending between the wedge main faces at said thin end of the wedge-shaped member,

the wedge-shaped slot having:

- a pair of slot main faces aligned to each other at said taper angle to form a thin end and a thick end of said slot, and
- 20 — a slot end face extending between the slot main faces at said thin end of the slot, and

said structures when engaged having:

- the wedge main faces opposing corresponding slot main faces and the wedge end face opposing the slot end face, and
- 25 — a gap formed between said opposing wedge main faces and slot main faces over most of the surface of those faces.

Preferably the solid product is formed of metal. Preferably the apparatus is a metal die casting apparatus.

30

The vent means may form a vacuum valve or may form a chill vent.

5

Said structures when engaged may form a gap between said wedge end face and said slot end face over most of the surface of those faces.

The surface of said faces, where said gap is present, may have a rippled surface. The
5 ripples may have a zigzag or serrated form or may have a sinusoidal form.

The vent means may comprise a vacuum valve adapted for solidifying product to close off a vacuum supply.

10 In one aspect the invention introduces a wedge-shaped chill vent. Like a conventional chill vent, it consists of two movable structures or blocks, but each has one or more wedge shapes opposite and offset each other. When the two blocks are engaged together, it forms a gap having one or more wedge-formations. In the vertical direction the gap possesses the same or similar zigzag shape as the known
15 conventional chill vent.

The vent means preferably includes a water cooling gallery internal to each of said structures.

20 A chill vent according to the present invention differs from a conventional chill vent in that the main faces of the invention are almost perpendicular, rather than parallel, to the die parting face. This more readily allows a limited space to have more than one vent aperture from the die cavity so as to increase the venting area without substantially increasing the die space. Moreover, the increase in the venting area
25 does not increase the projected area of the die, since the main faces of the vent are almost perpendicular to the die parting face. The present invention provides greater flow area for removal of air from a die cavity.

In another aspect the invention provides a method of casting or moulding a material
30 in a cavity in a die, said method comprising:

- connecting the cavity to a vacuum valve by way of a first conduit;

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- connecting a vacuum source to the vacuum valve by way of a second conduit;
- evacuating gas from the cavity through the first conduit, vacuum valve and second conduit to the vacuum source;
- 5 - injecting a quantity of melt of said material into the cavity to fill the cavity, said quantity being more than sufficient to fill the cavity;
- permitting some of the quantity of melt to flow from the cavity through the first conduit into the vacuum valve;
- cooling the die, the first conduit, and the vacuum valve to solidify said material therein such that the solidified material seals the vacuum valve and/or the first conduit;
- 10 - opening the die and the vacuum valve by separating portions of the die and the vacuum valve in a first direction,
- ejecting portion of said solidified material as said casting or moulding from the cavity, and ejecting portion of said solidified material from conduit and the vacuum valve in solid formation;
- 15

wherein said vacuum valve has two relatively moveable structures, a first of said structures having a wedge-shaped member which moves into engagement with a wedge-shaped slot in the second of said structures, said structures when engaged having a gap formed between said wedge-shaped member and said wedge-shaped slot within which said solid formation is solidified.

20

Brief Description of the Drawings

25 In order that the invention may be more fully understood there will now be described, by way of example only, preferred embodiments and other elements of the invention with reference to the accompanying drawings where:

Figure 1 is a simplified representation of high pressure die casting (HPDC) apparatus 10 for the cold chamber process as currently in commercial use;

30 Figure 2 is a perspective view of a first end plate main portion 50 of a chill vent apparatus according to one embodiment of the present invention;

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Figure 3 is a perspective view of the end plate main portion 50 together with a first narrow-face plate 100 aligned as for use;

Figure 4 is a perspective view of the components 50 and 100 shown in Figure 3 together with a first main face plate 150 aligned as for use;

5 Figure 5 is a perspective view of the components 50, 100 and 150 shown in Figure 4 together with a second end-plate mating portion 200 aligned as for use;

Figure 6 is a perspective view of the first end plate main portion 50 together with a first end plate mating portion 250 aligned as for use;

10 Figure 7 is a perspective view of the components 50, 100 and 250 shown collectively together with a second main face plate 300 aligned as for use;

Figure 8 is a perspective view of the components 50, 100, 150, 250 and 300 shown collectively together with a second narrow-face plate 350 aligned as for use;

15 Figure 9 is a perspective view of an assembly 453 of the components 50, 100, 150, 200, 250, 300 and 350 shown collectively together with a second end-plate main portion 400 aligned in the manner as for use as a chill vent body;

Figure 10 is a perspective view of a formation 502 that would arise if the gas flow passage within the assembly shown in Figure 9 is filled with metal, the orientation of the formation being the same as that of Figure 9;

20 Figure 11 is a perspective view of the formation 502 as viewed from a more elevated position;

Figure 12 is a perspective view of the formation 502 as viewed from slightly above horizontal;

25 Figure 13 is a perspective view of a typical formation 602 that is created by metal cooling in the assembly 453 during use; and

Figure 14 is a perspective view of an assembly 750 forming part of a chill vent apparatus according to another embodiment of the present invention.

Detailed Description of Examples of the Invention

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Referring to Figure 1, the HPDC apparatus 10 comprises a die 12 comprising a fixed half die 14 and a moving half die 16 which are brought into mutual engagement by

fluid actuated rams (not shown). The half dies 14 and 16 separate along a parting face 18. The half dies in engagement form a casting cavity 20 therebetween which has the shape of the product wished to be cast.

- 5 Molten metal is introduced to the cavity 20 by means of a high pressure injection system wherein metal is fed through a pour hole 22 into a shot sleeve 24 and a piston 26 on a plunger 28 first closes the pour hole 22 and then, in the same stroke, forces the desired amount of molten metal from the shot sleeve 24 through a runner 30 into the cavity 20. At the opposite end of the cavity a vent hole 32 allows gases and
10 excess metal to escape the cavity.

- Before molten metal is introduced to the cavity 20, the air in the cavity is evacuated through the vent hole 32 by means of a vacuum supply in a tank 34 connected to the vent hole 32 by way of a vacuum line 37 containing a solenoid actuated isolating
15 valve 36 and a vacuum valve 38 of one of the types discussed earlier in this specification. For simple vacuum systems the effective evacuating time is only a few seconds and is set by the travel time of the plunger 28 from covering the pour hole to the change-over position.

- 20 Referring now to Figures 2 to 9, the first main face plate 150 has an L-shaped frame portion 155 and a tapered engagement portion 157. The frame portion 155 has parallel opposed faces 159 and 160 (face 160 being hidden from view in the Figures) by which the plate 150 mates with corresponding parallel faces on neighbouring portion 200 and plate 100 respectively. The engagement portion 157 is wedge
25 shaped, having a pair of wedge main faces 162 and 163 (face 163 being hidden from view in the Figures) aligned to each other at a taper angle 164 and 165 of about 10° (identified on Figure 10). The engagement portion 157 has a thin end 166 at its end face 170 and a thick end 168 where it joins the frame portion 155.

- 30 Each wedge main face 162 and 163 has top face portion 172 and 173 respectively, which is flat, and a lower face portion 174 and 175 respectively which carries ripples 176 having a serrated form (saw tooth cross section) on its surface. Each ripple 176

extends along its respective face 162 and 163 from the thin end 166 to the thick end 168.

5 The end face 170 also carries horizontally extending ripples 184 which each join corresponding ripples on faces 162 and 163 to create an array of continuous ribs each rib extending across one main face 162, then across the end face 170, then across the other main face 163.

10 One leg of the L-shaped frame portion 155 forms a substantial fastening portion 180 extending upwards in the illustrations. The other, smaller, leg forms a base portion 182 of the frame portion and extends only half way along the engagement portion 157.

15 The first end plate main portion 50 is similar to the first main face plate 150 except that it has an angled and rippled face 62 on only one side while its opposite face 63 is flat and parallel to faces 159 and 160.

20 The first narrow face plate 100 has an L-shaped frame portion 105 like the frame portion 155 of plate 150 but, instead of having a tapered engagement portion like portion 157 of plate 150, the first narrow face plate 100 has an end face 136 carrying serrated ripples like those of face 170 of the first main face plate 150.

25 The second end plate mating portion 200 is similar to the first narrow face plate 100 except that it carries no ripples and the holes 202 and 203 are recessed to accommodate bolt heads (not shown).

30 The first end plate main portion 50, the first narrow face plate 100, the first main face plate 150 and the second end plate mating portion 200 are firmly bolted together in the configuration shown in Figure 5 to create a first block structure 450. A pair of fastening bolts (not shown) for this purpose pass through holes 52, 102, 152 and 202 and through holes 53, 103, 153 and 203 respectively.

10

The second end plate main portion 400, the second narrow face plate 350, the second main face plate 300 and the first end plate mating portion 250 are substantially the same as the first end plate main portion 50, the first narrow face plate 100, the first main face plate 150 and the second end plate mating portion 200 respectively
5 (although a significant difference is that the ripples are of opposite phase). They are firmly bolted together by bolts passing through holes 252, 302, 352 and 402 and through holes 253, 303, 353 and 403 respectively to create a second block structure 452.

10 Two threaded holes 188 and 189 in the top face 154 of plate 150 lead to a gallery for flow of coolant within the first main face plate 150 and the holes 188 and 189 provide an inlet and outlet respectively for the coolant. Similar pairs of holes 338, 339, 88, 89, 438 and 439 are provided in plate 300 and portions 50 and 400 respectively. A hole 341, blanked off at its outer end, provides gallery communication between holes
15 338 and 339. A corresponding blanked-off hole 441 provides communication between coolant holes 438 and 439, and corresponding holes (not shown) are also provided to link holes 88 and 89 and holes 188 and 189 to form respective coolant flow galleries.

20 The block structures 450 and 452 mate together to create a chill vent body 453 in which the engagement portion 307 of the second main face plate 300 is a wedge-shaped member engaged with a wedge-shaped slot 477 formed by opposed faces 62, 136 and 163. Similarly, the engagement portion 157 of the first main face plate 150 is a wedge-shaped member engaged with a wedge-shaped slot formed by opposed
25 faces of plates 300 and 350 and portion 400.

The first block structure 450 is securely fastened to the moving half die of the HPDC apparatus by way of bolts (not shown) extending through holes 142 and 192 in the frame portion 105 and the frame portion 155 respectively. Similarly the second block
30 structure 452 is securely fastened to the fixed half die of the HPDC apparatus by way of bolts (not shown) extending through holes 342 and 392 in the second main face plate 300 and the second narrow face plate 350 respectively. Thus in use the block

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structures 450 and 452 separate from each other in the same direction as the die halves separate.

5 While the opposed flat surfaces make a sealing contact when the structures are pressed together, there is a gap between all of the opposed rippled surfaces to provide a convoluted chamber 460 for capture and solidification of metal exiting the die cavity 20.

10 Holes 140 and 390 are provided through the fastening portions 130 and 380 of narrow face plates 100 and 350 respectively for connection to a vacuum supply. The holes 140 and 390 open into the upper portion of chamber 460.

15 Ejector pins 454 and 455 are provided in the second block structure 452 to facilitate clean removal of the solidified metal from the chamber 460. The pins 454 and 455 are actuated by springs or washers (not shown) which locate into respective sockets 456 and 457.

20 A threaded hole 193 is provided in the top face 154 of plate 150, and a threaded hole 343 is provided in the top face 304 of plate 300, whereby lifting means may be attached to facilitate lifting of the chill vent body 453.

25 The chill vent body assembly 453 is positioned in relation to the die in use such that the vent hole 32 of the die is held adjacent the vent inlet 464. The inlet 464 leads to a distribution rail 466 which in turn connects with the lowermost edge of each of the gaps.

30 In use air is evacuated from the chamber 460 through the holes 140 and 390 after the two structures are pressed together in engaged contact. The holes 140 and 390 are sufficiently distant from the vent inlet 464 for all the molten metal entering the chamber 460 to solidify before the level of metal reaches the holes 140 and 390.

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The formation 502 shown in Figures 10 to 12 illustrates the shape of the convoluted chamber 460 and comprises an array 504 of five rippled panels 510, 520, 530, 540 and 550 arranged sequentially in an edge to edge relationship. Three of the panels, namely panels 510, 530 and 550, are substantially larger than the other two panels 520 and 540 which link them. Panels 510, 530 and 550 are also linked across the centres of their bottom edges 511, 531, and 551 by a distribution runner 566 formed by filling of the distribution rail 466.

Panels 520 and 540 lie parallel to the runner 566 while the panels 510, 530 and 550 are angled at about 85° to panels 520 and 540. The array 504 of panels is thus arranged in an S-shape. Panels 510, 530 and 550 are aligned at an angle of about 5° to the direction (marked X-X on Figures 9 and 11) in which the block structures 450 and 452 separate.

The panels 510, 520, 530, 540 and 550 would be formed by filling of the convoluted gap between opposed rippled surfaces on the block structures 450 and 452. For example panel 530 would be formed by filling of the gap between faces 163 and 312 on the first main face plate 150 and the second main face plate 300 respectively.

The formation 602 shown in Figure 13 is an incomplete version of the formation 502 shown in Figure 10 and is created because the amount of molten metal which exits from the vent hole 32 in the die is insufficient to fill the chilling passage in the chill vent body, and is thus insufficient to produce the fully formed formation 502. It can be seen that the distribution runner 666 is fully formed (ie the same as runner 566 described above) as a result of the distribution rail 466 being completely filled. However metal has only partly filled the panel portions of chamber 460, to produce panels 610, 620, 630, 640 and 650 which are incomplete versions of panels 510, 520, 530, 540 and 550 as the top portions are missing.

Surface coatings may be applied to the rippled surfaces in order to improve their performance. The roughness of the rippled surfaces may be enhanced in order to improve their performance.

It has been found from tests that when this vent is connected to a vacuum system with a vacuum tank 34 and solenoid valve 36, it can achieve at least the same or even better evacuation efficiency than a conventional vacuum valve, because:

- 5 1. It provides an increased cross sectional flow area (horizontal plane in Figure 9) for a given gap between the two halves of the vent. This enables more air to be extracted from the die due to less flow restriction.
2. The gas flow passage is open until the end of the cavity fill.
- 10 The cross sectional flow area of a vent may be readily tailored to any particular application by adding an appropriate number of paired main face plates and narrow face plates in a modular manner.

15 Another advantage of the above-described vent is that the geometry leads to all the metal which solidifies in the vent being joined together enabling easier and more reliable ejection with less problems from separate pieces stuck in the vent.

 Since the flow passage is shut off by the solidified metal, there is no need for any additional moving parts to act as a mechanical vacuum valve. Thus the present
20 invention is a more robust device which is particularly advantageous because such mechanical vacuum valves are difficult to maintain in the HPDC process.

 This invention thus has advantages over both the conventional chill vent and the vacuum valves currently used in the die casting industry.

25 A further embodiment of the invention provides a chill vent apparatus having two block structures brought together much as described above in relation to other embodiments, but which removes the need for much of the bolting of components. The two block structures are generally the same, except for minor aspects, and are as
30 shown in Figure 14. The block 710 has a surrounding case 712 fabricated from steel and having a rectangular box-like configuration with an open face. Within the case 712 are mounted four inserts (namely an endplate 720, a centre spacer 740, a main

face plate 760 and an end spacer 780) which slide together firmly into place as a neat fit within the case 712.

5 The main face plate 760 is located towards the centre of the inserts. It is tapered in the manner of the tapered engagement portion 157 described above. Wedge faces 762 and 764 on respective obverse sides of the insert 760 each carry an array of ripples 768. The end face 766 does not have ripples thereon and in this respect differs significantly from the structure of the tapered engagement portion 157.

10 The endplate 720 has an angled rippled face 724 on one main face and a flat main face 722 on the obverse side. Its end face does not have ripples thereon. The flat main face bears snugly against an end wall 713 of the case 712 and the rippled face 724 is angled at about 5° to the flat main face 722.

15 The centre spacer 740 is tapered on obverse faces in one direction so as to fit snugly against angled faces 724 and 762, and is also angled on its top face 742 to engage with a mating block.

20 The end spacer 780 has a flat face on its side bearing against the end wall 714 of the box, and is angled on its top face 782 to engage with downwardly facing face 728 on a mating block.

25 When two blocks 710 are mated together for use, the end faces 766 and 726 bear against the inside of the back 717 of the case which also has no ripples. Accordingly the structure of the formation of solidified metal produced from this embodiment has no smaller panels corresponding to panels 520 and 540 described above.

30 A significant benefit of using a case 712 to contain the components is that it can serve to reduce air leakage into the chamber 460 when vacuum is applied.

Whilst the above description includes the preferred embodiments of the invention, it is to be understood that many variations, alterations, modifications and/or additions

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may be introduced into the constructions and arrangements of parts previously described without departing from the essential features or the spirit or ambit of the invention.

- 5 For example, although the embodiments described above have the chill vent connected to a vacuum, the use of a vacuum is not essential. The chill vent may be used without a vacuum connection and testing has shown that in such a configuration the chill vent is 3 to 4 times more efficient than a conventional chill vent.
- 10 Also, the embodiments described have a taper angle 164 and 165 of about 10° but the exact angle is not particularly important providing the block structures 450 and 452 fit together neatly and the draft angle is sufficient to reliably achieve ejection of the formation 502. The wedge shape is not even limited to a sharp angle, so the angle 164 could be greater than 45° . Furthermore angles 164 and 165 could be different to
- 15 each other.

The end faces 136 and 186 are described as having ripples covering them completely. However these faces may carry ripples on only some or even none of their surfaces. Conversely, although the embodiment described with reference to Figure 14 has no

20 ripples on its end face 766, variations thereof which fall within the scope of the invention do have ripples on that face in the same manner as the ripples 184 seen in Figure 4.

The rippled end faces 136 and 186 have been described as substantially planar, and

25 joining the wedge main faces (eg. faces 162 and 163) at respective edges 194 and 195. Alternatively the end faces (such as end face 186) may be curved, and may be cured so far that they blend into the main faces (eg. faces 162 and 163) without or with minimal edges 194 and 195.

30 The ripples may be any convenient shape but an abrupt zigzag formation has been found to be particularly suitable.

16

The blocks 450, 452 and 710 described all have many components requiring assembly. The invention envisages those blocks (or their equivalents) being made as a single unitary item.

- 5 The present invention may act as a valve when vacuum is applied or may act as a vent when no vacuum is applied, even for the same configuration.

- Some embodiments of the invention do not have a gap between the wedge end face and the slot end face so that in the solidification chamber corresponding to chamber
10 460 no panel portions are produced which are parallel to the runner 666.

- It will be also understood that where the word "comprise", and variations such as "comprises" and "comprising", are used in this specification, unless the context requires otherwise such use is intended to imply the inclusion of a stated feature or
15 features but is not to be taken as excluding the presence of other feature or features.

- The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that such prior art forms part of the common general knowledge in Australia.
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- Dated this 1st day of October 2003
25 CAST Centre Pty Ltd
by their patent attorneys Morcom Pernat

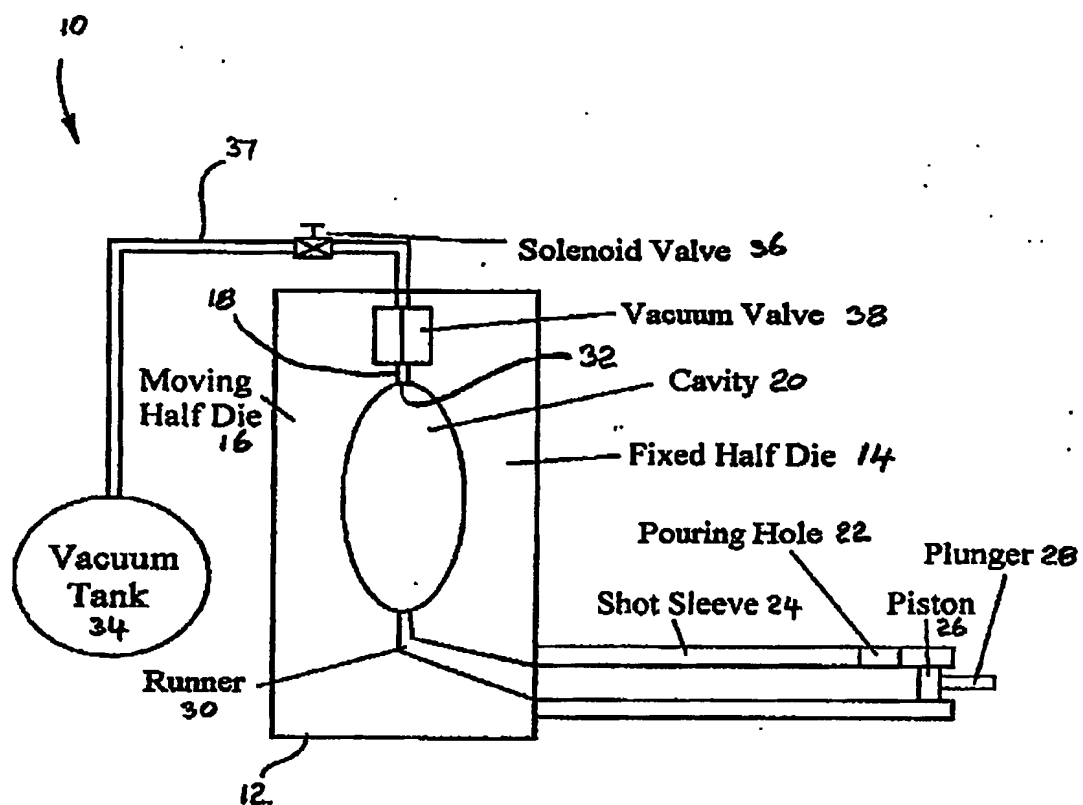
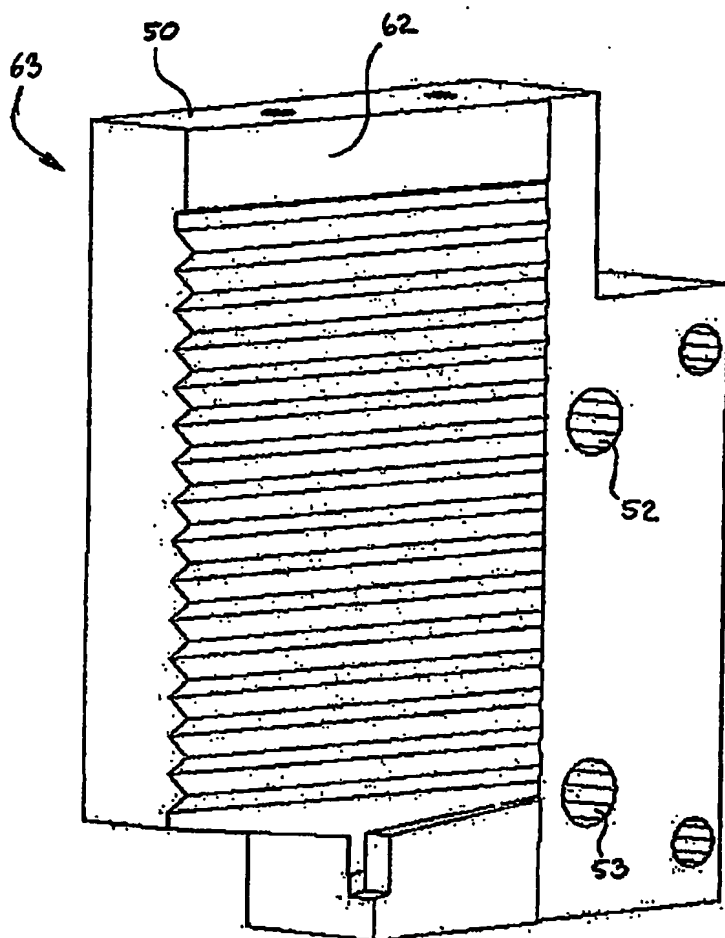


Fig. 1

*Fig. 2*

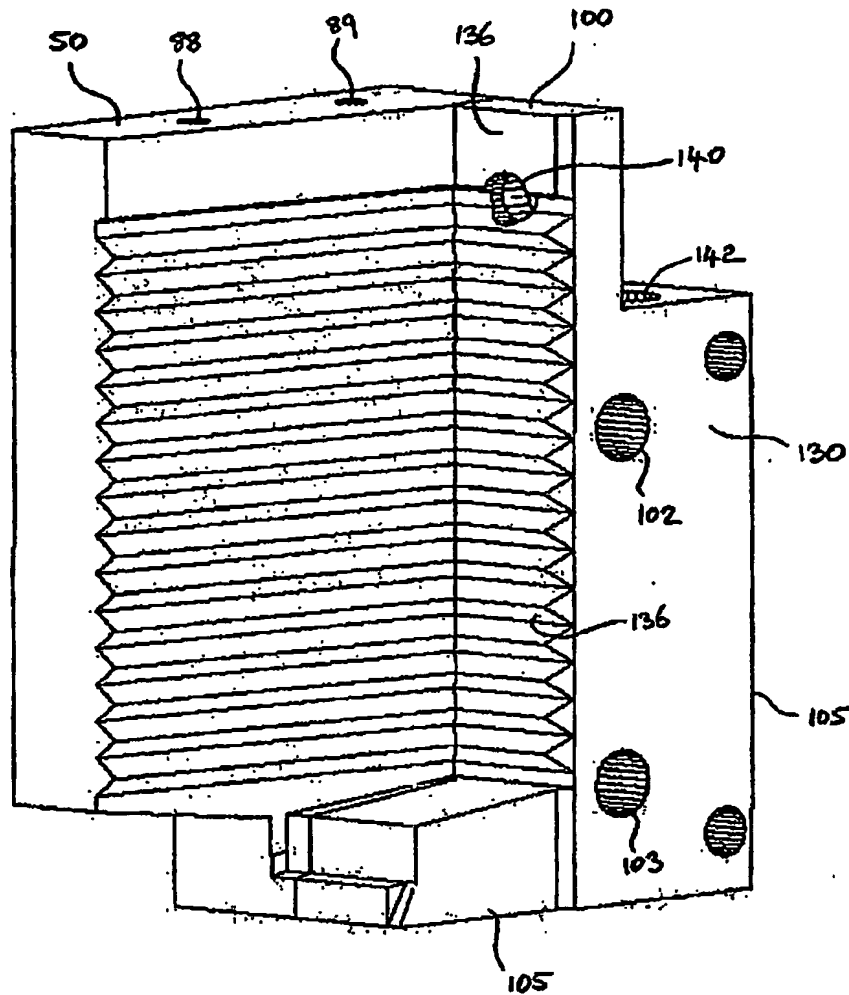


Fig. 3

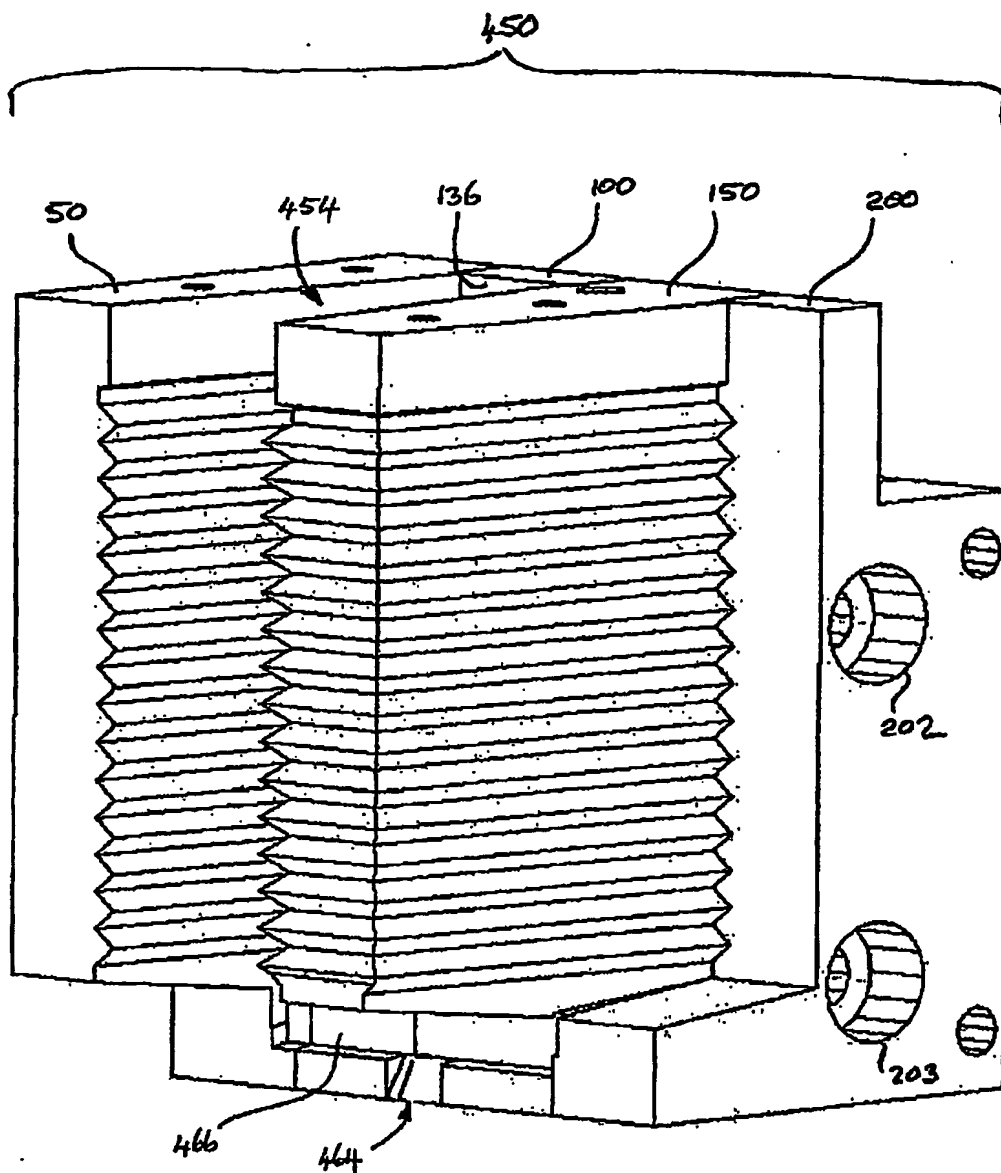


Fig. 5

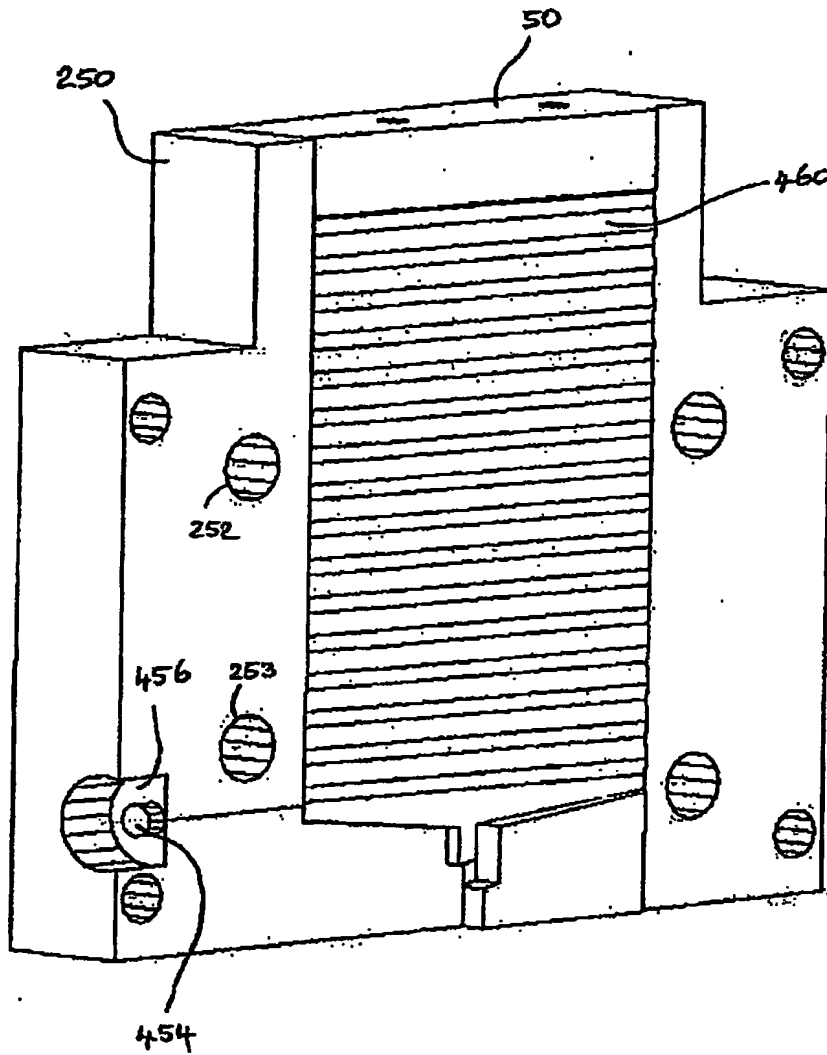


Fig. 6

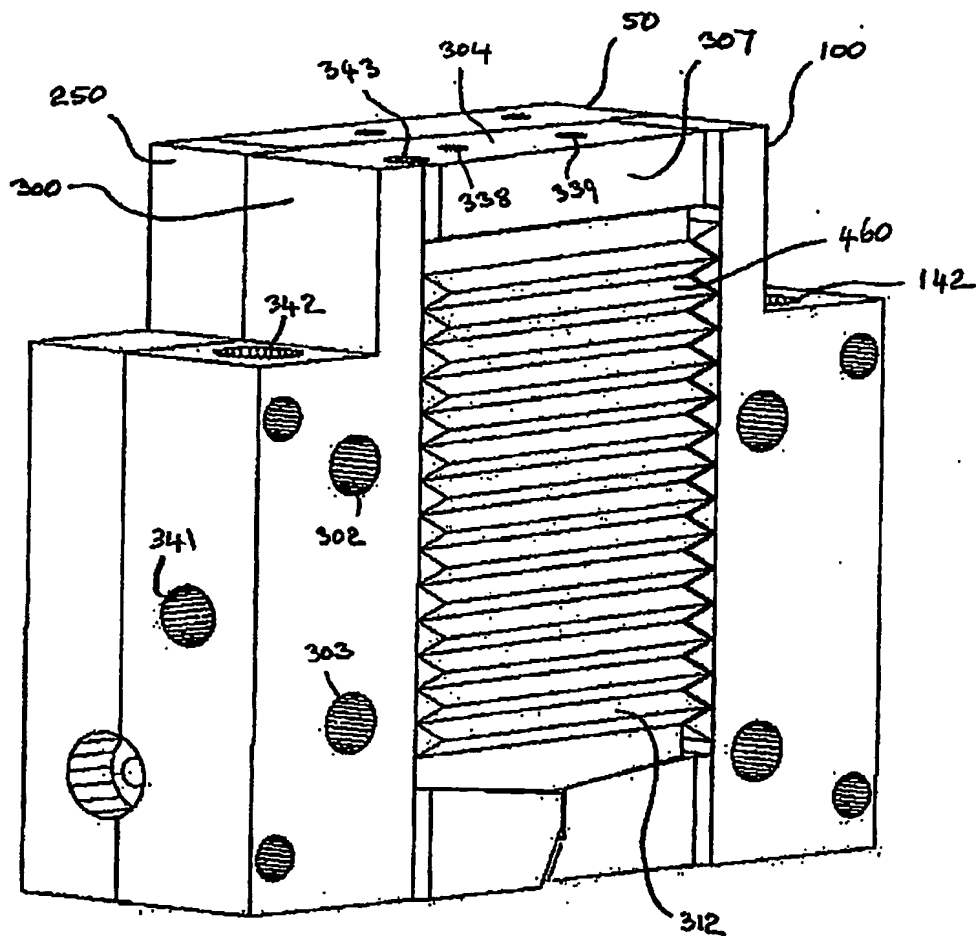


Fig. 7

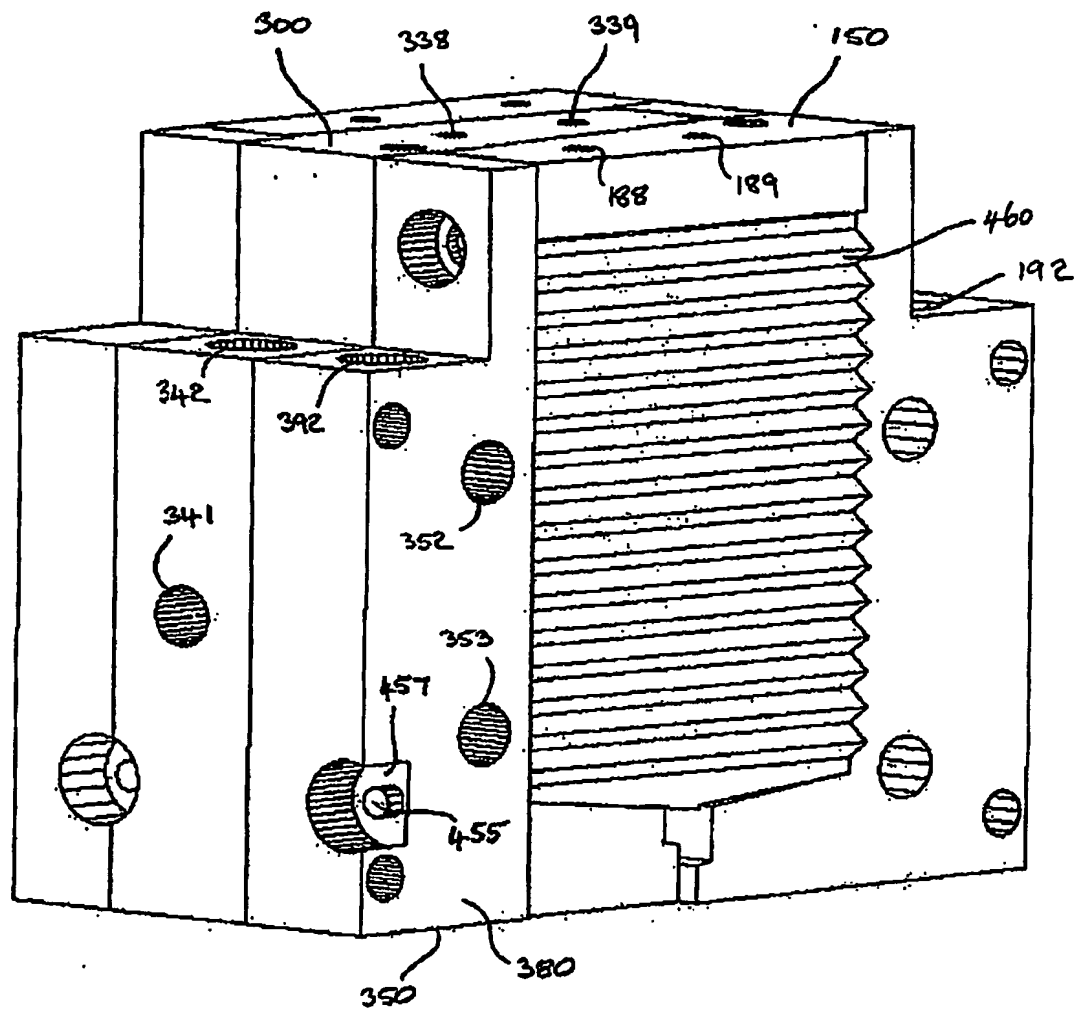


Fig. 8

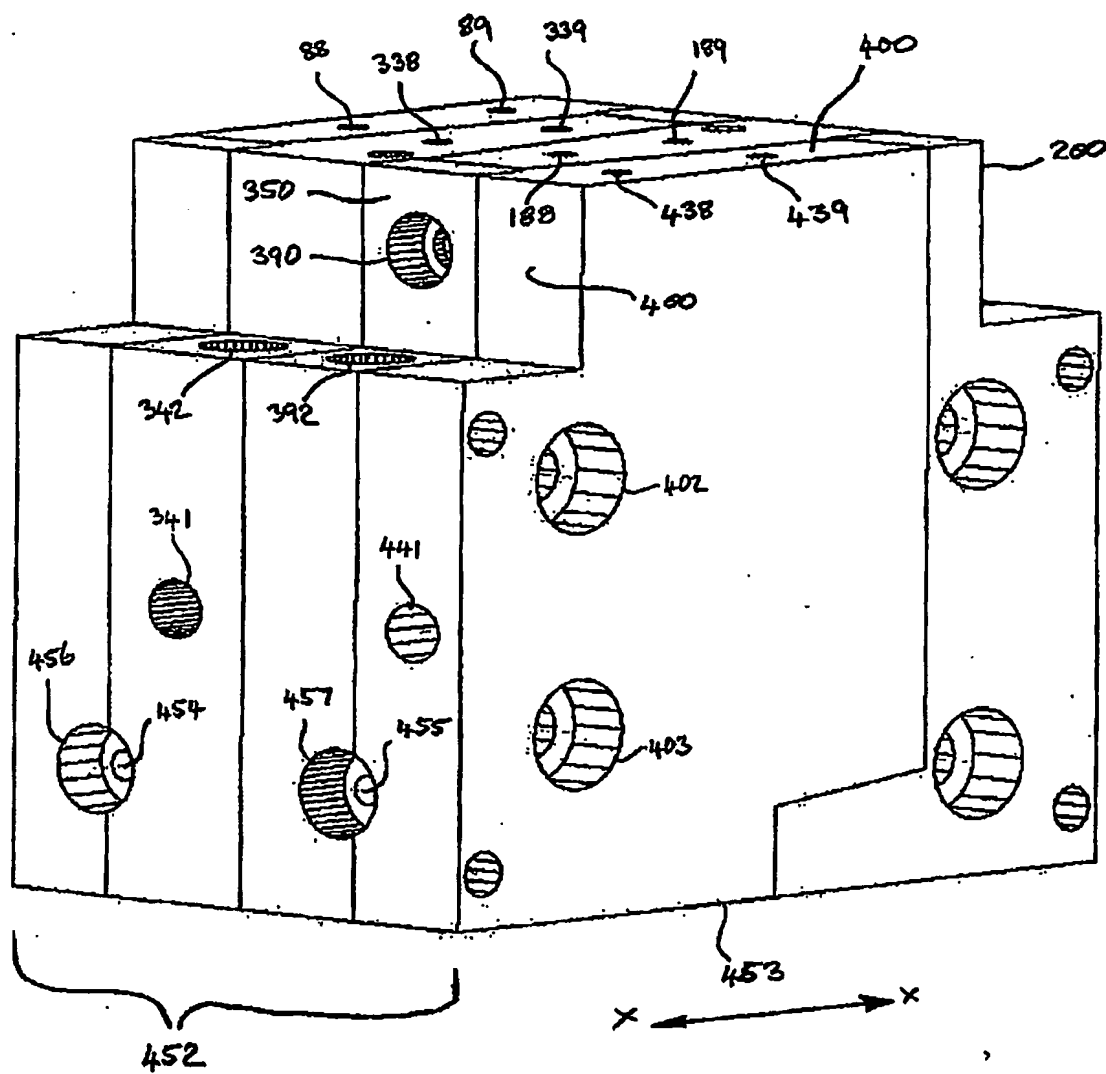


Fig. 9

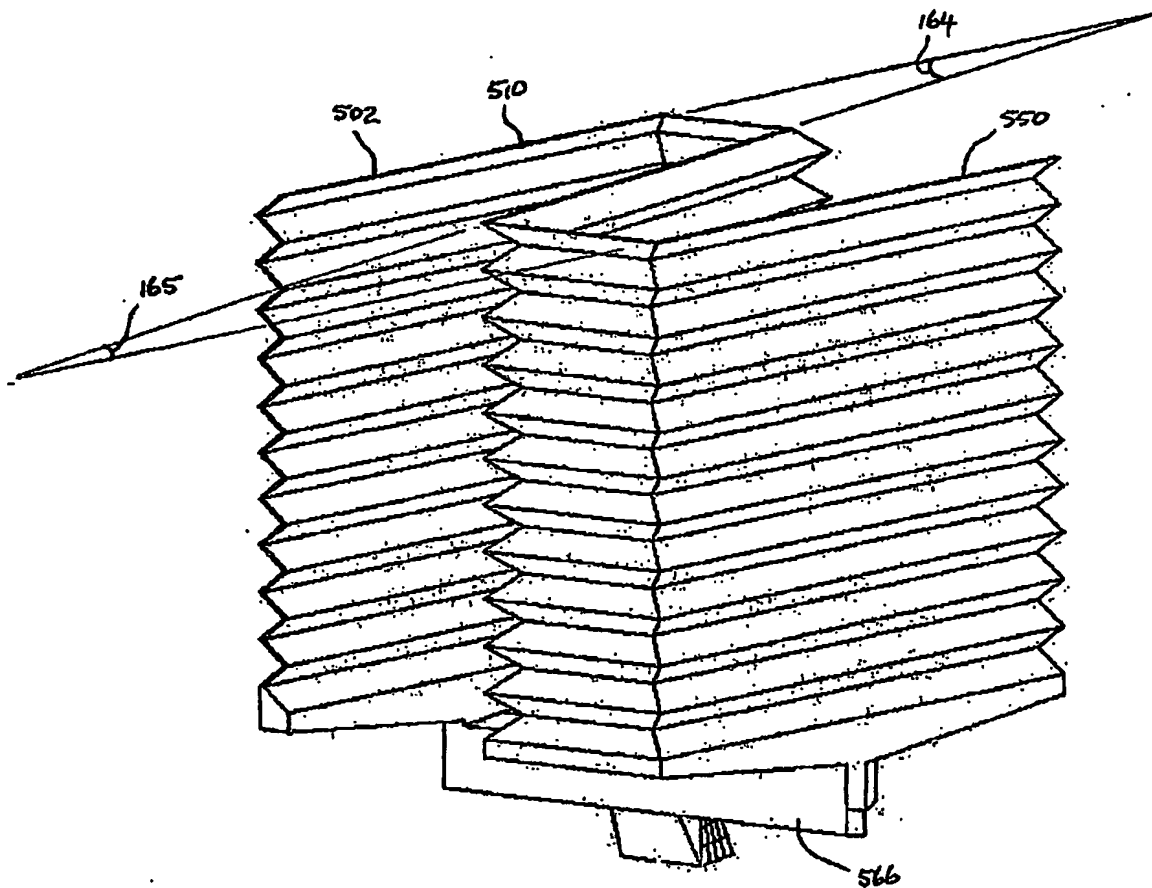
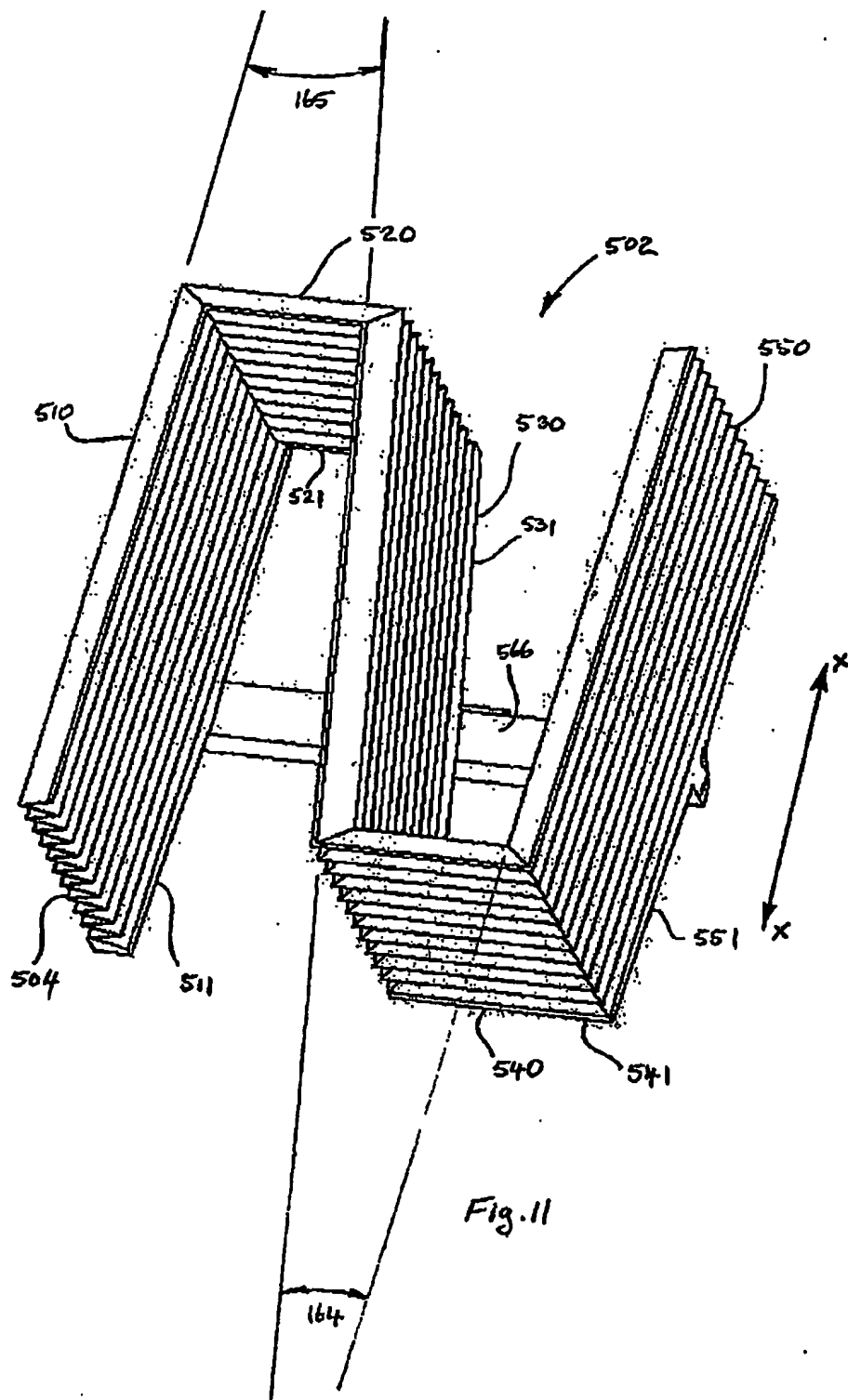
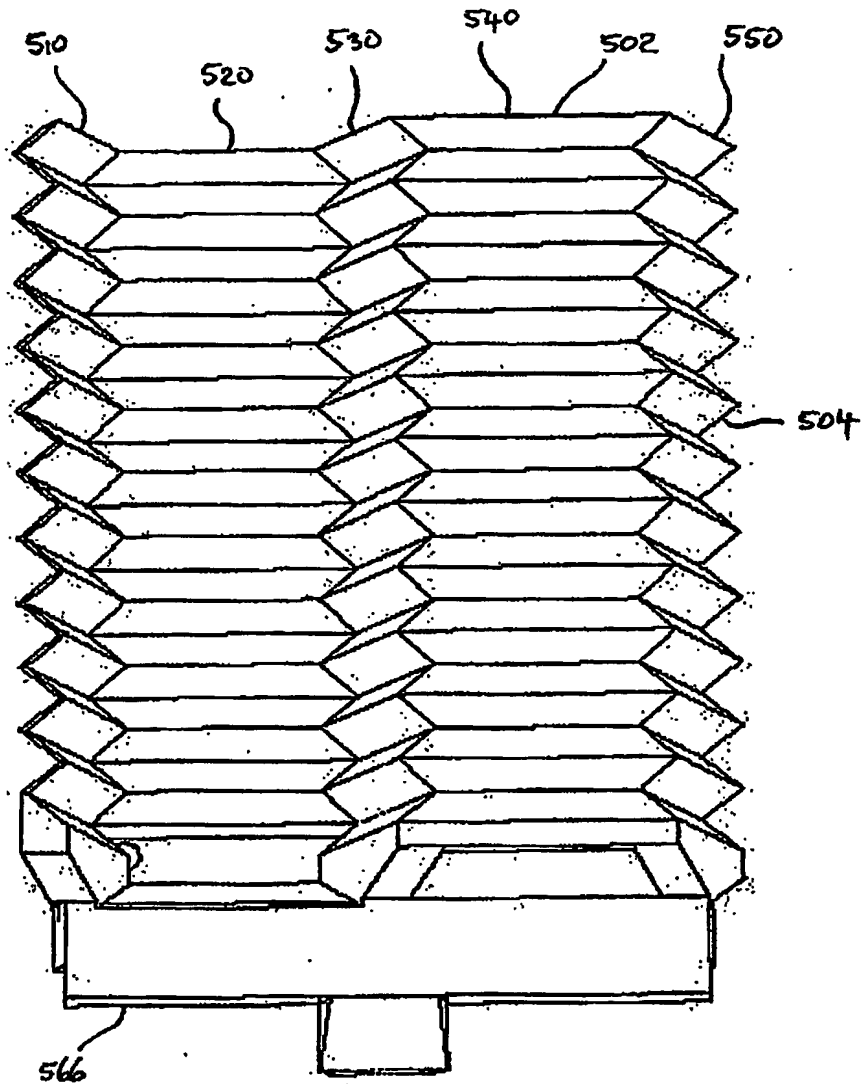


Fig. 10



*Fig.12*

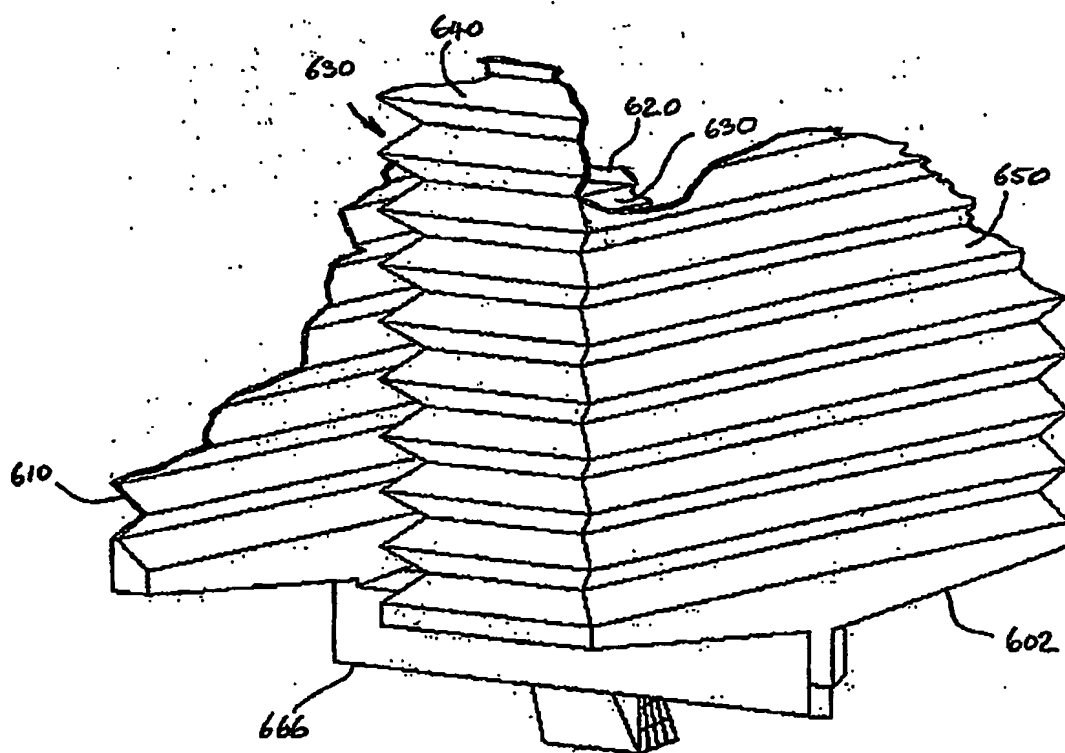


Fig. 13

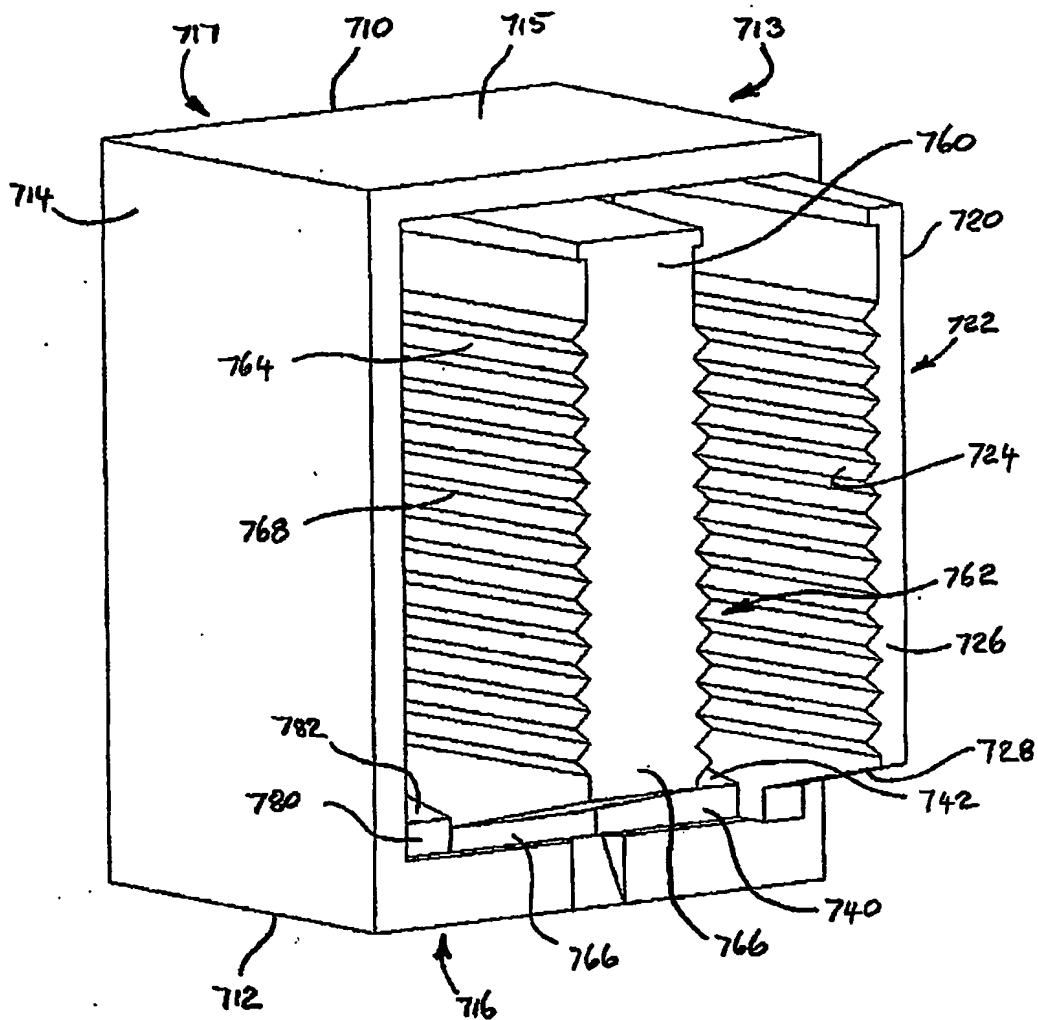


Fig. 14

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